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# Toward an international program for offshore storage of $CO_2$: International Initiative for CCS sub-sea (iCCSc).

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**Abstract**

Offshore geologic settings worldwide add to widely distributed high-volume storage resource needed to reduce $CO_2$ emissions at scales and for durations needed for global atmospheric benefit. Definition, access, and demonstration of offshore storage resources can increase engagement of many countries in emissions reduction negotiations. A research capacity-building initiative is needed to focus on both proving up global geologic capacity offshore and developing international technical capacity to utilize offshore storage resources. Such an initiative must leverage the strengths of the collective technical experience and financial capacity of international governmental, industrial, and academic/research organizations to distribute the costs and risks associated with large-scale offshore CCS. One long-term success criteria of such an effort could be an accelerated path for offshore demonstration projects.


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## 1. Introduction

Many nations are committed to a variety of energy transition and emission reduction targets, and variable timelines and metrics have been put forward with respect to emissions. The latest report from IPCC emphasizes the important role CCS can play for emissions reduction goals. However, progress in emission reductions via CCS has been challenging, with many gains offset by newly-recognized hurdles, both financial and technical. From the last decade of work on CCS, three aspects are evident:

Costs are high. These relate primarily to capture, transportation, siting, liability, development, and monitoring aspects. They are surmountable, but scaling up from pilot projects, especially in offshore settings, remains challenging. If costs, risks, and technological outcomes can be shared, progress is more likely.

Time is critical. Regions that do not see potential for geologic storage may unacceptably slow the process of adoption. Demonstrating additional proven storage resource can accelerate progress.

Geographic distribution of onshore storage is not uniform. Suitable onshore storage sites are geologically widespread but unequally geographically distributed, presenting potential global geopolitical challenges for consensus on CCUS. Subsea storage may provide an answer to nations with a need but little onshore storage, for example India, and for nations with some onshore storage but likely not enough, for example China.

### *1.1. Current Examples*

Although not an exhaustive list, examples of current and future interests in offshore storage are shown in Figure 1. Sleipner and Snohvit were executed by an excellent and very experienced North Sea hydrocarbon exploration company, Statoil and partners. These commercial gas separation facilities are effective in proving that subsea storage can be accomplished, but these projects do not complete the global capacity-building mission or develop a robust global storage database on which governments can base policy decisions.

Offshore $CO_2$ geologic storage potential is not well characterized globally, although some individual countries have performed more in-depth characterization and analysis. Europeans and Australians recognized early that offshore potential was their primary geo-sequestration target. The U.S. is now beginning to look at offshore potential[1], but also realize that it is a critical resource (note the eastern seaboard of U.S.). There is also a need to understand and address technical challenges associated with operating a CCS project in a marine environment.


Fig. 1. Global examples of current and currently proposed prospective locations for offshore $CO_2$ storage.

## 2. Important considerations

Offshore CCS provides excellent opportunities for achieving near-term emissions reduction targets, but challenges exist.

- *Nationally-owned and managed resource*: Permitting a site under a single governmental entity presents advantages over siting issues in privately owned or managed onshore settings.
- *Widespread capacity*[2-3] *at low risk:* Favourable offshore settings are common to many nations and represent the majority of global storage (Figure 2). Risks to communities and protected groundwater are removed in offshore settings and monitoring opportunities are favourable.
- *Favourable infrastructure; source-sink proximity*: Most large industrial emission areas are in coastal settings, providing the ability to *match emissions sources and sinks*. Often existing pipeline right-of-ways exist.
- *Energy liquids upside*: Cost displacement is possible via $CO_2$-EOR and development of existing $CO_2$-rich natural gas fields for global LNG market (e.g. SE Asia; Pre-salt of Brazil; NW shelf, Australia).
- *Technology*: CCS can drive new technological developments and economic growth. Offshore CCS will require specialization of existing technologies leading to development and broad application of new industrial technology.

Additionally, offshore geologic storage offers several additional advantages over onshore storage, such as:

- Avoids issues with heavily populated, onshore areas (Figure 2).
- May require only one owner for leasing and pipeline siting.
- Reduces difficulty of surface and mineral owner rights, in areas where jurisdiction can be an issue.
- Reduces risks to underground drinking water sources.
- Provides storage opportunities in areas of many large emission sources along coastlines, and areas that may have potentially limited options for onshore storage.

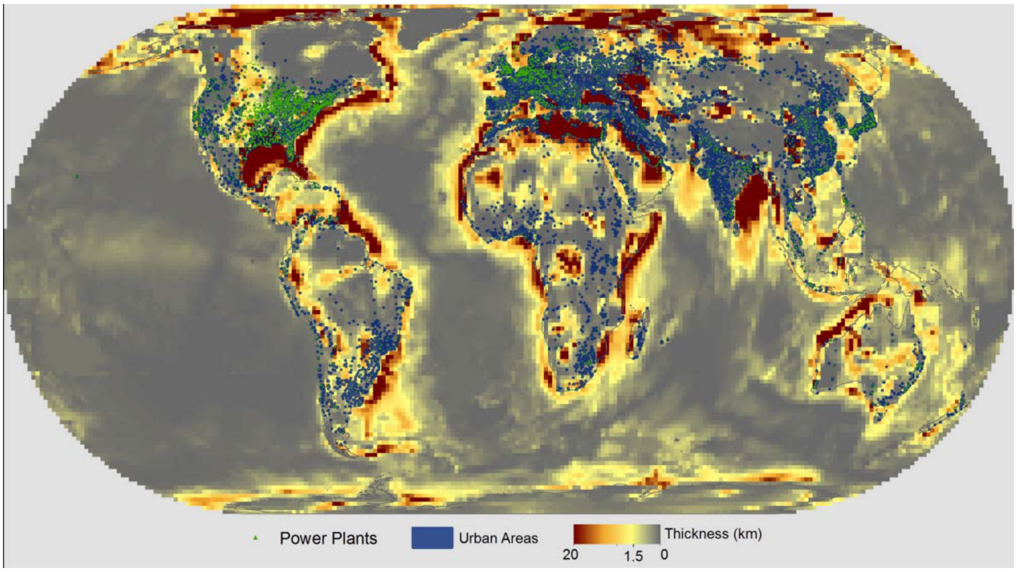


Fig. 2. Stratigraphic thickness[4-5] relative to population centres[6] (blue) and $CO_2$ sources (green). Population density in some cases is not near onshore potential. In other cases dense urban areas interfere with use of nearby, onshore sinks because of public concerns. Note that many concentrations of sources have nearby offshore basins for storage.

## 3. Example Roadmap

Below is an example roadmap for a phased implementation of a capacity-building effort. It does not represent a fixed scenario, but rather a template for discussion and further refinement.

*PHASE I: Scoping & Program Definition*

- Identify key participants based on broad agreement for action, experience and diversity. Engage existing centers of excellence in offshore geologic storage and link with areas of need for capacity development.
- Conduct high-level scoping meetings to frame goals and identify structure.
- Broaden participation worldwide, develop funding.
- Solicit input and participation from stakeholders in research, industry, NGO's, and governments.

*PHASE II: Characterization & Site Identification*

- Conduct regional geologic characterization for identifying suitable storage resources and capacity estimates.
- Identify key research and development topics specific to each region that may naturally integrate into common themes. For example: (Working groups)
    - Infrastructure (source-sink matching, pipelines)
    - $CO_2$ management of gas (LNG) development
    - Capacity assessment
    - EOR optimization
    - Basin-scale geologic fluid systems performance
    - Drilling and (subsea) completion technology
    - Regional risk commonalities and variability
    - Monitoring strategies and technologies
- Further refine stakeholder concerns and implement strategies for addressing them.
- Define most prospective development opportunities for each region characterized, driven by key research and development topics identified above.

*PHASE III: Field demonstration Projects*

- Pursue pilot project(s) for most viable sites, based on geology, industrial support, funding, cost, research and development advances, and likelihood of success.
- Continue additional site-specific characterization via existing or newly-acquired data.
- Develop infrastructure (capture, pipelines, offshore template), drilling, injection, and monitoring.
- Transfer knowledge of key technological advances to facilitate global implementation.

## 4. Opportunities for involvement

While there are many good technical reasons to proceed, there appear to be barriers to collaborative progress. We take a lesson from the collaborative model that was successful in getting the first field demonstration project (Frio[7]) kick-started and also from the model successfully used in the U.S. Department of Energy (DOE) Regional Carbon Sequestration Partnership (RCSP) program. Frio collaborators included DOE-NETL, two national labs, the U.S. Geological Survey, 2 international research groups, and a suite of commercial entities. Most RCSP projects have dozens of collaborators across all sectors.

With this broad partnership model in mind, a new task force of the Carbon Sequestration Leadership Forum has been established. The task force will focus on identifying technical barriers and research and development needs and opportunities for offshore sub-seabed storage of $CO_2$. The results of this task force will be summarized in a formal report. General topic areas for the report include:

- Identify existing projects and characterization activities worldwide on offshore $CO_2$ storage and progress to date;
- Provide a current assessment or understanding (using available analyses) on the status of global offshore storage potential (including potential for offshore enhanced oil recovery (EOR));

- Identify the technical barriers/challenges to offshore $CO_2$ storage (e.g., characterization, monitoring, transport challenges) and R&D opportunities;
- Identify potential opportunities for global collaboration; and
- Include conclusions and recommendations for consideration by CSLF and its member countries.

The time has come for major international collaboration on technologies and deployment of large-scale, deep subsurface, offshore geologic CCS.

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